QUESTIONS IN SCIENCE TEXTBOOKS: DO THEY PROMPT STUDENTS' INQUIRY AND PROBLEM-BASED LEARNING?

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Abstract: Problem-based learning (PBL) is an inquiry-based learning approach that fosters the development of students' autonomy as learners, and enables them to develop life-long learning competences. Problems and their underlying questions are building blocks of PBL approaches. Thus, questioning in science classes and textbooks can foster the development of students' inquiry and problem-solving competences. As teachers' teaching practices seem to depend on textbooks, this study compares the way the three Physical and the three Natural Sciences most sold textbooks deal with questions when developing the Earth in Transformation curriculum theme. This analysis focuses on: localization and function of the questions; nature of the answers demanded; and cognitive level of the questions. Results reveal that: only Natural Sciences textbooks use questions in the opening of the theme and its units; Physical Sciences textbooks have larger numbers of questions than the Natural Sciences ones do, being most of them connecting and knowledge application questions; both subjects' textbooks are similar in what concerns using questions as section titles and giving explicit answers to questions; Physical Sciences textbooks have a much larger number of non-guided answer demanding questions; whatever the subject, the number of high-level thinking demanding questions is low. These findings indicate that most science textbook questions can hardly promote student's inquiry and PBL.

Keywords: questions, science textbooks, inquiry, problem-based learning, Earth in Transformation

INTRODUCTION

School plays a major role in the formation of the individuals' personality, making them more responsible, better informed and more critical while ensuring that they will be able to use knowledge adequately. Studies indicate that it is impossible to ensure scientific literacy using traditional methods. As such, it is very important that the process of learning science becomes increasingly meaningful, relevant and interesting. It is equally imperative that students become more active participants.

Questioning is considered to be fundamental to the learning process as it encourages students to find solutions to different problems. One of the most important objectives of formal education is to develop students' autonomy as learners.Thus, it is important to understand the best ways to encourage and promote questioning by students.This requires high-level thinking as well as learning how to develop competences. Solving problems and answering to high level questions may foster the development of those competences (Wragg & Brown, 2001).

Problem based learning is an inquiry-based learning approach where problems play a major role acting as a stimulus for students' learning. This method uses daily problems as a point of departure for the learning process (Lambros, 2004). The problem is introduced at the beginning of the unit of study, ensuring that students know what they are learning and why they are learning it, thus increasing their motivation. In this way, all information gathered by

students is learnt with the purpose of solving a problem (Chin & Chia, 2004). According to this method, the learning process begins with the identification of the problem itself. Students are confronted with a scenario generally related with the real world. The latter promotes debate among students as well as they resolve to discover something relevant to their personal daily lives. Students formulate questions that help to diagnose their knowledge and their difficulties. Through this process, students learn to identify their prior knowledge about a subject, their related learning needs, and the best way to solve the problem and achieve relevant knowledge on the subject (Dahlgren & Öberg, 2001; Chin & Chia, 2004). In an inquiry-based learning approach, students should question, examine books and other sources of information, propose hypotheses, analyse data, propose conclusions and communicate the results. As De Boer (2004) says, although students achieve different independence levels within this approach, students are indulged to develop their problem-solving capability, preparing them to be self-oriented and concerned citizens.

Questioning, either in science classes or in textbooks, can work as a privileged strategy for students to develop PBL competences. However, not all questions are useful for this purpose. In fact, only questions that require understanding and high order thinking can be useful within a PBL framework. Science textbooks include questions with different characteristics and purposes when they develop content topics.

Although the Portuguese Educational System Law (law number 49/2005, 30 August) advocates science textbooks as an important educational resource, research has shown that textbooks are conservative with regard to the way they develop curriculum themes, forgetting problems and questions as important ways to promote cognitive development (Leite et al., 2011).

As teachers' teaching practices seem to be dependent on textbooks, this research study compares the way the three Physical and the three Natural Sciences most sold textbooks deal with questions when developing the Earth in Transformation curriculum theme. Results may help teachers and teacher educators to become aware of the potential of textbooks as inquiry promoting tools within the scope of PBL and to find out ways of overcoming their limitations, if necessary.

Questioning

For Dewey (1933), a question is a way to evoke, to provoke or encourage inquiry.

A question may be conceptualized as an issue put forwards for discussion in such a way that it demands an answer. Hence, questions are associated with problems, as both include a sort of obstacle that needs to be overcome by the respondent or problem solver.

The formulation of questions is a frequent activity in our daily lives and also in the classroom. In the context of the classroom, the question is particularly important and even considered the essence of the learning process. It creates imbalances that encourage students to seek for new solutions (Giordan & Vecchi, 1996).

To accomplish their role as curriculum development mediators, school textbooks should foster the development of students' questioning and problem-solving abilities. There is some evidence that Portuguese school science textbooks include many questions, even though some of them cannot be associated to problems, as they do not require, at least, comprehension of the science issues (Dourado & Leite, 2010). Assuming that questions may be the start of a meaningful discourse, textbooks should use questions as a starting point for developing the curriculum theme, and its teaching units, sub-units or sections, in order to foster students'

cognitive and affective engagement with the issues to be addressed. Some textbooks do this more often than others but when they do it a few of those questions are left unanswered (Dourado & Leite, 2010).

Questioning has concentrated many researchers' attention and has been investigated from diverse angles, including questioning in the classroom, teachers' questions, students' questions, textbooks questioning, etc. Literature (Wragg & Brown, 2001) indicates that: teachers ask too many questions, and that most of them are not only low level questions but also questions that are not supposed to be answered by the students; students are not used to be asked to formulate questions but when they have the opportunity to do so, they do it very satisfactorily. However, the cognitive level of students' generated questions seems to depend on the characteristics of the problem context that elicits them (Dalghren & Öberg, 2001).

Several question taxonomies emerged from research undertaken. Some of them draw heavily on the cognitive requirements of the questions and follow Bloom's Taxonomy of educational objectives; others pay some attention to procedural competences and therefore combine cognitive-based and procedural-based categories; others include also value-laden categories. Dalghren & Öberg (2001) defined a taxonomy of students' formulated questions that follows the latter pattern. It includes five categories as follows: Encyclopaedic Questions, demand an unambiguous and not complex answer (e.g., What is a fossil?); Meaning-Oriented Questions, oriented towards finding a phenomenological meaning of certain terms or concepts (e.g., How can the study of meteorites help to understand the structure of the Earth?); Relational Questions, focus on relationship between aspects/ features (e.g., What is the relationship between the different types of rocks?); Value-Orientated Questions, demand for a judgment based on some criteria (e.g., To what extent is nuclear energy a safe alternative to fulfil the world energy needs?); Solution-Oriented Questions, focus on looking for solution(s) for a problem (e.g., Write an essay on the energy crises focusing on what can be done in order to reduce the excessive use of fossil combustibles and the energy crises).

METHODS

To attain the objective of this study, the three Physical (PS) and the three Natural (NS) Sciences most sold (in 2010/2011) textbooks dealing with the Earth in Transformation curriculum theme were content analysed. The analysis was based on a checklist based on Dahlgren & Öberg (2001) and Dourado & Leite (2010)). The analysis focused on the questions included in the selected textbooks but excluded questions given within learning activities (e.g., questions on data analysis of a given lab activity included within the lab worksheet). Data collection was done by two of the authors, after a deep discussion of the checklist. Due to space restrictions, quantitative results will be presented per subject only.

RESULTS

Physical Sciences textbooks include a larger number of questions than the Natural Sciences ones (table 1: PST- 403; NST- 135), due to their large number of application questions (242).

As shown by table 1, Natural Sciences textbooks present questions when opening the theme or its units. This is consistent with a PBL approach. Whatever the subject, textbooks use questions as section titles and to guide students with regard to expected learning results. This is consistent with an inquiry perspective and relevant for guiding students through the sections too. As far as the nature of the answer demand is concerned, the two groups of

textbooks are similar except in that the Physical Sciences ones give guidance to students to answer to a large number (272) questions and Natural Sciences do not.

Table 1. Number of questions per dimension, category and subject

Dimensions of analysis	**Categories | sub-categories**		**NST (n=135)**	**PST (n=403)**	**Total (538)**
Localization of the question	Opening of the theme		9	0	9
	Opening of Units		31	0	31
	Title of sub-units		0	27	27
	Title of sections		49	36	85
	Throughout a sub-unit or section text	Integrated into the content being presented	5	39	44
		After the content presentation	1	242	243
		Resolved questions	0	12	12
		Other	2	0	2
	Associated to learning activities	Activities title	30	1	31
		Activities statement	8	30	38
	End of the sub-unit or section		0	16	16
Function of the question	Present expected learning results		40	27	67
	Present the text to be developed		3	36	39
	Link parts of a text on a given issue		53	39	92
	Present learning activities	Explicitly optional activities	2	0	2
		Explicitly compulsory activities	34	31	65
	State knowledge application activities	Explicitly optional activities	1	16	17
		Explicitly compulsory activities	0	242	242
	Illustrate problem solving processes		0	12	12
	Try to keep readers' attention		2	0	2
Nature of the answer demand	Answer ignored		4	9	13
	Answer given	Explicitly	118	122	240
		Implicitly	8	0	8
	Answer required to students	Without guidance	0	0	0
		With some guidance	5	272	277

It should also be emphasised that, whatever the localization of the questions, the cognitive requirements for giving a successful answer to most of them are very low, as most questions are encyclopaedic (table 2). Relational, value-oriented and solution-oriented questions were hardly found.

Table 2. Cognitive level of the questions according to their localization in the textbooks (f)

Localization of the questions	Types of questions									
	Encyclopaedic		Meaning-		Relational		Value-oriented		Solution-	
	NST	PST	NST	PST	NST	PST	NST	PST	NST	PST
A	9	0	0	0	0	0	0	0	0	0
B	16	0	9	0	5	0	1	0	0	0
C	0	11	0	16	0	0	0	0	0	0
D	43	16	4	20	1	0	1	0	0	0
E	1	25	3	14	1	0	0	0	0	0
F	0	184	0	57	1	0	0	0	0	1
G	21	0	5	1	2	0	2	0	0	0
H	0	14	0	15	1	0	7	0	0	1
I	0	5	0	11	0	0	0	0	0	0

Legend- A: Title of the theme; B: Title of the unit: C: Title of the sub-unit; D: Title of the sections; E: throughout a sub-unit or section text (integrated into a text being presented); F: throughout a sub-unit or section text (after content presentation); G: associated to learning activities (activity title); H: associated to learning activities (activity statement); I: end of sub-unit or section.

This result may be due to the fact that traditionally textbooks in Portugal don't include many problems or questions for students to solve or to see how they can be solved. In addition, the Portuguese curriculum is not a Problem-Based Curriculum, fact that does not help teachers to embrace problem solving or demand students to question.

CONCLUSIONS AND IMPLICATIONS

Physical Sciences and Natural Sciences textbooks differ in what concerns the number of questions they include as well as with regard to the way they use the questions. Although both groups of textbooks seem to acknowledge an inquiry based approach, Natural Sciences textbooks seem more consistent with a PBL approach as they use questions as the starting point for developing the theme and its units. On the other hand, even in Natural Science textbooks, most of the questions are encyclopaedic demanding a low cognitive level to give a correct answer. However, research is needed in order to find out how the textbook authors deal with those opening questions, especially in terms of what is supposed to be done and by whom to answer them. To analyse the answers given to these questions is a relevant issue for a deeper judgement of the potential of textbooks as PBL promoters.

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